i-SAIRAS 99 Paper Submission

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TITLE: Autonomous Rock Tracking and Acquisition from a Mars Rover

Autonomous robotic operations can greatly increase the science return of planetary missions. As these operations become more adaptive, the burden of planning a sequence of motions is moved from the human operator to the onboard control system, allowing a greater number of targeted experiments to be achieved. Future Mars exploration missions will perform two types of experiments: science instrument placement for close-up measurement, and sample acquisition for return to Earth. In this paper we describe algorithms we developed for these tasks, and demonstrate them in field experiments using a self-contained Mars Rover prototype, the Rocky 7 rover.

Our approach combines vision processing with vehicle and arm control. The target is identified in an image by a human operator, and its 3D location is computed onboard using stereo vision. An arc toward the target point is planned, and executed in small steps. The shape of the terrain immediately around the target is used to reacquire the target at each step; we servo on the elevation map instead of image features, because the latter are subject to abrupt scale changes during the approach. This allows us to compensate for the poor odometry that results from motion on loose terrain, by visually reaquiring the target at each step. Vehicle motion stops when the target appears within the workspace of the arm that will be used to grasp or study it.

Field experiments have shown that we can successfully grasp a 5cm long rock over 1m away using 120-degree field-of-view stereo cameras, and can place a flexible mast on a rock outcropping over 5m away using 45 degree stereo cameras.